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U. S. DEPARTMENT OF AGRICULTURE.

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THE ENTOMOLOGIST

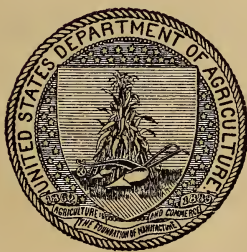
FOR

1910.

BY

L. O. HOWARD.

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REPORT OF THE ENTOMOLOGIST.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 8, 1910.

SIR: I submit herewith an executive report covering the work of the Bureau of Entomology for the fiscal year ending June 30, 1910, dividing it, in accordance with your instructions, under the following headings:

(1) A summary of the important operations carried on during the fiscal year ending June 30, 1910.

(2) An outline of the plans proposed for work during the fiscal year ending June 30, 1911, under appropriations already made for that year.

(3) Plans of work recommended for year ending June 30, 1912.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

WORK OF THE YEAR.

The work of the year beginning July 1, 1909, and ending June 30, 1910, may be classified, as was the case last year, as follows:

- (1) Work on the gipsy moth and the brown-tail moth.
- (2) Importations of useful insects.
- (3) Exportations of useful insects.
- (4) Work on insects injurious to southern field crops.
- (5) Investigations of insects damaging forests.
- (6) Investigations of insects damaging deciduous fruit trees.
- (7) Cereal and forage-plant insect investigations.
- (8) Work on insects affecting vegetable crops.
- (9) Work on insects affecting citrus fruits.
- (10) Investigations of insects in their direct relation to the health of man and domestic animals.
- (11) Work on insects injurious to stored products.
- (12) Inspection work.
- (13) Work on bee culture.
- (14) Unclassified work.

FIELD WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

The work against the gipsy moth and the brown-tail moth during the fiscal year ending June 30, 1910, has been continued along lines similar to those used in previous years, with a few modifications and additions. The infested area is somewhat larger, but the rate of increase is proportionately less than it has been in any year since the beginning of the work. Except for the finding of a bad colony of the gipsy moth at Wallingford, Conn., all the additions to the territory have been contiguous to the previously infested areas. The cooperation with the state authorities in the infested States has been most cordial and effective, and the livable conditions in the older infested areas are better than at any previous period since 1900. This means that the streets, roadsides, and cultivated lands are measurably free from both pests. Spread has been in forested areas, and looking away from the roadsides toward forested hillsides it was possible at any period during July to find large ranges of browned trees indicating the almost total removal of the foliage. As indicated before, however, the death of forest trees does not necessarily follow a complete defoliation in July, since the coming of rains in August brings out another crop of leaves, thus saving the trees from asphyxiation. Moreover, it is becoming evident that it is only rarely that the same area is completely defoliated two years in succession. It much more commonly occurs that the bulk of the caterpillars in a large infestation bringing about complete defoliation die as the result of disease from overcrowding, or from starvation owing to the complete destruction of food; hence the following season the new infestation begins on the borders of the old one, and contiguous rather than identical areas are defoliated.

The work, as in the past, has been confined chiefly to the gipsy moth. The infested area in New England is now little more than 10,500 square miles.

There has been little increase in the area infested by the brown-tail moth within the past year. The territory which this insect is now known to inhabit is about one-third of the extent of New England.

WORK IN MASSACHUSETTS.

The work in Massachusetts has been principally in the way of keeping the most traveled woodland roadsides through the worst-infested areas clear of the gipsy moth, and has been a continuation of previous work in nearly every direction, except south, where the conditions are not so serious as they are north and west of Boston. The roadsides which have been cared for more than one year are in such condition as to require a constantly lessening annual expense, and in a few instances additional work may be discontinued, since the roads are so clear that the towns are willing to care for them themselves. It seems that the Bureau may be able to induce the towns to take over more of the work which it has been caring for. As shown in previous reports, the strip on either side of the road which has been cleaned up has been 100 feet in width. Experimentally during the past year in several instances this width has been reduced to 75 and 50 feet. If these narrower belts prove to be effective in keeping the caterpillars from roadways, an extension of the number of miles of roadsides covered can be gained with the same appropriation.

Spraying operations were begun at the end of May and continued to the end of the fiscal year. Ten large spraying machines were kept at work in Massachusetts on the roadsides through the worst-infested woodlands, and some work was done in New Hampshire. The spraying was not so successful this year as last, on account of the unusual number of rainy days, the rain preventing the application of the poison and washing off much of that which was applied.

WORK IN NEW HAMPSHIRE.

No summer work was done in New Hampshire in 1909, but in the latter part of October scouting operations were begun, and an effort was made to keep 100 men in the State during the winter; but it was not easy to maintain this number on account of the difficulty of getting men who were willing to leave home. A severe blizzard and snowstorm late in December coated the trees and covered the ground to such a depth that scouting operations had to be discontinued temporarily. The work was continued into June, 1910. All of the previously known infested territory was scouted, but not so thoroughly as in previous years, the seriousness of the infestation in the southern part of the State rendering it desirable to spend the time in applying creosote to the egg clusters along the roadsides. The orchards and woodlands away from the highways were not touched.

During the fiscal year 1908-9 about 50 towns were added to the infested area; the present year 21 were added as the result of this careful scouting. In several of these new towns only single egg clusters were found, and in none of them were there any large colonies. There are at present 121 infested cities and towns in New Hampshire, with an area of about 3,500 square miles. There seems to be little hope of controlling the gipsy moth in New Hampshire until a local organization is effected in each city and town, under state supervision, and a constant concerted effort is begun. The scouting operations were continued outside the area found to be infested, in order to make certain that there has been no further spread.

The brown-tail moth situation in New Hampshire was found to be serious. The winter nests were removed from the highway trees in most of the towns, and many property owners cut them from orchard and shade trees near their dwellings, but here again there is necessity for concerted state and township work.

WORK IN MAINE.

In Maine the trees in the infested localities were burlapped and tended. The worst places were sprayed. In most of the woodland colonies the underbrush has been cut out and the trees put in the most favorable condition possible. Scouting operations were continued throughout the winter and spring months. Four towns were added to the infested area, but in these only incipient infestations were located, the worst one being at a market garden in South Portland, where 22 egg clusters were found and treated with creosote. All of the known infested localities in this State are in shape for future work. The territory now known to be occupied by the gipsy moth in Maine is about 800 square miles. The gipsy moth colony previously existing, and referred to in earlier reports, at Soldiers' Home,

Togus, Me., may be considered as exterminated, no evidence of the moth having been found for nearly two years.

During the past winter considerable woodland scouting was carried on, and large gipsy moth colonies were located in a few places, the worst one being on the eastern slope of Agamenticus Mountain, in the towns of York and Wells. Several thousand egg clusters were treated with creosote in this colony, and the ground was cleared up over several acres. A smaller colony was located near the summit of the mountain. Several woodland colonies were located in the Berwicks, but Maine conditions in general are not bad.

The brown-tail moth seems possibly to have reached the northern limit at which it can thrive in Maine, which is about the forty-fifth parallel of latitude. Although the moth has been known to be present up to this line for two or three years, it does not appear to increase materially. This statement must not be taken as a prediction that the brown-tail moth will not extend north of this region, but simply as a statement of observed fact down to the present time.

WORK IN RHODE ISLAND.

The area infested by the gipsy moth in Rhode Island has decreased slightly during the past year, and the moth is less abundant than at any time since its control was undertaken. The Bureau work in this State has been in cooperation with the state officials. The state appropriation is used until it is exhausted, and then such of the force as is necessary to keep up the work is carried on the federal pay roll through the season. The creosoting of egg clusters and the burlapping of trees has been the principal work. A little brush has been cut and a great many trees have been cemented or patched with tin to lessen the number of hiding places for the caterpillars and egg clusters.

The brown-tail moth has been more in evidence in Rhode Island during the past year than before, and now occurs in about one-fourth of the State—the northeastern portion—although here it is not as prevalent as in Massachusetts, New Hampshire, and Maine.

WORK IN CONNECTICUT.

The gipsy moth colony at Stonington is nearing extermination. Less than 100 caterpillars were taken there during the summer of 1909 by the state force. Early in December some of the best scouts employed by the Bureau were sent to this State to assist the state authorities in the search for egg clusters, the combined efforts resulting in the discovery of but one. While this colony will need watching for some time, it seems probable that another year or two should result in its complete eradication.

In December, 1909, a bad colony of gipsy moths was discovered in the town of Wallingford, about 12 miles north of New Haven. The State immediately took steps to do the necessary work, and a little later a force of Bureau scouts was sent down from Massachusetts to examine the territory outside of the lines of the original colony. Every tree in Wallingford was examined, except the woodland, and no egg clusters were discovered except a few near the border of the colony, as at first outlined. The scouting operations were continued

in the towns of Meriden, Berlin, and New Britain, but no evidence of the existence of the gipsy moth has been found in these towns. It is hoped to continue this line of scouting operations to the Massachusetts state line in the towns through which a great deal of traffic passes from the infested area in Massachusetts to New York. This is one of the principal automobile routes in New England. All effort to ascertain how the gipsy moth reached Wallingford has been vain. The colony has existed for about three or four years, and possibly longer, entirely undiscovered until last December. *About 10,000 egg clusters were destroyed before hatching time. The State is doing all of the work in the infested area.

The brown-tail moth has been reported from Thompson, in the northeast corner of the State, and also at Putnam, a few miles south of Thompson. It is possible that this region south of the Massachusetts line is rather generally infested.

GENERAL CONSIDERATIONS.

There have been employed throughout the year from 300 to nearly 500 men. First-class men have been difficult to get, and in February an increase was made in the wages of all of the older men, of from 1 to 3 cents per hour. There have been in use 10 gasoline-power spraying machines, of 400 to 500 gallons capacity, capable of discharging 3,000 to 4,000 gallons per day, and about 40 tons of arsenate of lead have been used during the past spraying season.

The use of burlap bands for trapping the caterpillars on the tree trunks has been discontinued, and tree tanglefoot has been substituted, 20 tons being used during the summer work of 1910. In an effort to reduce the cost of this operation, similar substances have been introduced from Europe, but have not proved to be as effective as the tanglefoot in the prevention of the crawling of the caterpillars.

Some investigations have been begun in regard to certain points connected with the life history of both the brown-tail moth and the gipsy moth, which, although hitherto considered settled, now seem open to some doubt.

The principal subject of this kind which has received attention has been undertaken in an effort to explain the presence of the gipsy moth in isolated woodland colonies which it could not possibly have reached by the crawling of the caterpillars and which it is most unlikely to have reached by being carried accidentally on the garments of persons penetrating the woods. Thus a series of experiments has been carried on in a most careful way to determine whether the newly hatched gipsy moth caterpillars may be distributed by the wind, and it has been possible to prove during the summer that the newly hatched caterpillars have been carried in this way over a distance of 1,800 feet.

The methods used in the entire work, together with new observations bearing upon the work, have been summarized in a bulletin about to be published, entitled "Report on the Field Work against the Gipsy Moth and the Brown-tail Moth," by D. M. Rogers and A. F. Burgess. One new point brought out is that August spraying is an excellent method for the control of the brown-tail moth. The collection of the winter webs, which is the method universally adopted in Europe and which has also been generally practiced in this

country, necessitates the constant cutting back of the twigs and smaller branches, which, where the moths are so plentiful as to make their webs upon almost every twig, must be to some extent injurious to the trees.

Although there is a general section in this report devoted to inspection work, it is proper here to mention the efforts made to prevent the further dissemination of the gipsy moth from the infested territory by the cooperation of the different railroads running through this territory. Beginning with the fiscal year 1909-10, the several railroads issued a notice to all of their station agents (about 600 in number) within the infested area to the effect that forest products, such as lumber, cord wood, railroad ties, telephone poles, etc., would not be received for transportation unless accompanied by a permit or a certificate of inspection. The effect of this order was some disturbance to shippers for a time, but, as they learned the object of the inspection and saw the possibility of relieving others of similar inconvenience, they have gladly cooperated. A trial of this plan indicated that it was nearly impossible to inspect all of the material offered for shipment, and permits were granted without inspection for the transportation of forest products from one infested locality to another infested locality, but all of the products intended for shipment beyond the infested territory were carefully inspected and all egg masses were destroyed before the material was moved and before a certificate was granted to the shipper. In December, 1909, a supplementary order was issued by the railroads to their station agents stating that forest products for shipment from one station to another within the infested territory might be received and shipped without permit or certificate. This order properly gave a list of the stations on the several roads between which material might move, but forbade the transportation of forest products from the stations listed to stations not listed, except when accompanied by a certificate. Three thousand four hundred and seventy-five applications were made for shipment, and 2,751 permits were granted, 724 certificates being issued. This system has worked fairly satisfactorily, although it is not perfect.

The actual field work just described has been carried on under the direction of Mr. D. M. Rogers, as in previous years. Mr. Rogers's headquarters are at No. 6 Beacon street, Boston.

IMPORTATIONS OF INSECT ENEMIES OF THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

The principal efforts of the Bureau in importing useful insects during the fiscal year 1909-10 have been in connection with the importation of the parasites and predatory enemies of the gipsy moth and the brown-tail moth from other parts of the world. This work has been in cooperation with the State of Massachusetts, and the parasites have been received at the Gipsy Moth Parasite Laboratory, supported by the State, at Melrose Highlands, the care of the parasites and their distribution being assigned to the Bureau of Entomology. The laboratory has been increasingly busy and increasingly effective, and during the fiscal year has employed 23 assistants, the principal experts being carried on the rolls of the Bureau of Entomology and the others being paid by the State. Mr. W. F. Fiske, of the Bureau, has had direct charge of the work.

The writer visited Europe in May and June, 1910; visited agents and officials in Italy and France, and, through the courtesy of the Spanish and Portuguese governments, was able to start a new official service in each of these countries for the collection and sending of parasitized gipsy moth larvæ to the United States. In Italy Prof. F. Silvestri, of the Royal Agricultural College at Portici, and Dr. Antonio Berlese, director of the Royal Agricultural Entomological Station at Florence, insisted on the desire to be of service to the United States in this direction and declined all financial aid. In Spain Prof. L. Navarro, of the Phytopathological Station at Madrid, volunteered his services under the same conditions, with the approval of the minister of agriculture. In Portugal, Prof. A. F. de Seabra, of the Phytopathological Station at Lisbon, also volunteered his services with the permission of Senhor Alfredo Carlos Le Cocq, director of agriculture. In France arrangements were made with a paid agent stationed in the south of France, and the same arrangements as in previous years were made with paid agents in Germany and Switzerland. The distributing agency at Hamburg was continued, and a new distributing agency was started at Havre on account of its convenient proximity to the American Line steamers starting from Southampton.

Sendings from Japan were continued in the same manner as during the previous year. The minister of agriculture for Japan, at the request of the Secretary of Agriculture of the United States, again designated Prof. S. I. Kuwana, of the Imperial Agricultural Experiment Station at Tokyo, to be its official representative in the work to be carried on during the spring and summer of 1910. Professor Kuwana continued his most valuable sendings.

The thanks of the United States Government and of the governments of the States involved are due in high measure to the officials of Italy, Russia, France, Spain, Portugal, and Japan who have assisted in this work. All of them have been named at one time or another in this series of reports.

The work of the Gipsy Moth Parasite Laboratory continued uninterruptedly during the year, consisting of—

(a) Importation of parasites and predatory enemies from abroad, as indicated above.

(b) Rearing these parasites and predatory enemies in the laboratory, and wherever possible breeding them in numbers from imported parent stock.

(c) Colonization in the field of the parasites thus obtained.

(d) Field work to determine their progress in America.

(e) Investigations into their biological and general relations.

(f) Field and laboratory investigations into the parasites of native insects most nearly related to the imported pests either in habit or in natural affinity, with especial reference to the probable effect which the introduction of the foreign parasites will have upon the economy of the native parasites and of their hosts.

Larger quantities of the raw material from which the parasites have been reared have been received than during any other year. This has consisted, as heretofore, of eggs, winter nests, caterpillars, and pupæ of the brown-tail moth from Europe, and of eggs, caterpillars, and pupæ of the gipsy moth from Europe and Japan, large numbers of adult predatory beetles, and thousands of parasite cocoons and

puparia. But, for numerous reasons, although the amount received was larger, the results obtained, owing partly to the condition of the material on receipt and owing to curious seasonal fluctuations and differences in the countries of origin and in the infested territory in America, the results have by no means corresponded with the increased material.

During the year 1909 two important parasites of the gipsy moth (*Blepharipa* and *Parasetigena*) were imported in large numbers. They were both hibernated successfully and colonized under ideal conditions in the spring of 1910.

During 1910 determined efforts have been made to secure adequate numbers of several interesting and probably valuable parasites not yet secured in quantities sufficient to provide for satisfactory colonies; but for the most part these attempts seem to have resulted in failure, although the final word can not be said at this time.

As the work goes on there seem to be almost as many disappointments as successes. For example, no less than 1,000,000 of a Japanese parasite of the eggs of the gipsy moth were reared during the summer of 1909 and the winter and spring following, and great hopes were entertained for its success, but from the present point of view it appears to be wholly unable to withstand the rigors of the New England winter, and another egg parasite, a European species, of which several hundred thousand were reared in confinement, does not appear to make an impression upon the numbers of the gipsy moth eggs in America.

On the other hand, success of the most promising character has been reached with others of the imported species. *Calosoma sycophanta*, an imported European predatory beetle, was the first of the imported species to be recovered from the field under circumstances indicative of its ability to exist under American conditions. The season of 1910 is the fourth during which its progress has been conscientiously followed, and during each of these seasons it appears to have combined a steady rate of increase of approximately tenfold with a rate of dispersion in excess of 1 mile a year in every direction from the center of the original colony. A tenfold rate of increase annually means that 100 beetles liberated in 1906 would have increased to 1,000,000 by 1910, and the actual prevalence of the beetle in the field is such as to make this appear a reasonable estimate of the numbers actually existent. They were so abundant in some localities the past year as to affect the gipsy moth materially, although by no means so materially as to meet and overcome the strong reproductive ability of the pest. If, as there is reason to hope, they will continue to increase at this slow but steady rate for some years to come, their effect upon the present prevailing abundance of the moth will be apparent to all.

Another encouraging example is the tachinid fly of the genus *Compsilura*, which attacks both the gipsy and the brown-tail caterpillars as an internal parasite. This species was first liberated in 1906 and was first recovered in 1909 under circumstances indicative of its establishment in America. During 1909 it was found distributed over about five towns adjacent to the one in which the first infected colony was liberated. It was everywhere rare during that year. In 1910 it was expected that it would show a marked increase, but the actual outcome was in excess of all expectations. Instead of a ten-

fold increase, which would have been considered satisfactory, there seems good evidence that it increased fiftyfold and perhaps much more. It has about equaled *Calosoma* in actual destruction of gipsy moths this year, and in addition has destroyed an appreciable percentage of the brown-tail caterpillars, and it is now turning its attention to such native species as the fall webworm, the tussock moth, and other fall-feeding caterpillars. Its increase has been accompanied by a dispersion amounting to 10 or 12 miles in every direction as a minimum aggregate during the four years since its first colonization.

Still another example is the European *Monodontomerus*, the recovery of which over a large area was made the subject of especial mention in the last report. This species has continued its satisfactory rate of increase and phenomenal rate of dispersion throughout the year. It is well over the border line in New Hampshire, and appears to be extending its range about 10 miles each year, and to be maintaining a twenty-five fold annual increase.

It has been somewhat disheartening in the course of the study of the progress of the parasites in the field to find that certain species liberated under the most favorable conditions can not be recovered the next year; and even in the case of two species, both colonized in 1908 and apparently established in 1909, no traces could be recovered in 1910. But on the other hand another species (*Zygobothria*), colonized in 1907, was recovered in 1910, three years later, for the first time—in small numbers, it is true, but over a considerable territory, indicating a rapidity of dispersion sufficient to render a material increase unnoticeable for the first two years.

Another encouraging fact which may be mentioned here is that an important egg parasite (*Anastatus bifasciatus*) seemed this summer to have demonstrated its ability to survive the New England winter, and, having been colonized in 1909, appears to be strongly established in 1910.

On the whole, the results of the work are distinctly more encouraging than they have appeared to be heretofore, and we are by no means disheartened over the nonrecovery during the present season of no less than 15 species which have been colonized. In several instances colonization has been much too recent to make their recovery probable, on account of rapid dispersion; and several others have never been received in sufficient numbers to make a strong colony possible, so that it may well be that establishment has not yet been accomplished. It has been found in the course of this work that there is little hope of the establishment of a colony of less than 1,000 individuals, and in many instances, of course, it has been found impossible to put out so large a number.

The insight which is being gained at the laboratory into many points connected with the biology of these important and interesting insects is resulting in practical knowledge that can not fail to be of high importance in the continuation of the investigation. Some changes in plans will be indicated in another part of this report.

OTHER IMPORTATIONS OF USEFUL INSECTS.

The greatly increased damage done in portions of Massachusetts by the European leopard moth, an insect whose larva bores into the limbs of many shade trees, and which at present is confined to eastern

Massachusetts and to the vicinity of New York City, has rendered it desirable to attempt the importation of some of the known European insect enemies of this species. This effort has been made during the fiscal year, but it is too early as yet to observe any result. Further attempts were made to introduce European enemies of the elm leaf-beetle, but as yet without success.

It has been ascertained that the eggs of the tobacco hornworm in Porto Rico are destroyed by parasites, and in consequence, through the courtesy of Prof. W. V. Tower, a large number of parasitized eggs were sent to Clarksville, Tenn., the headquarters of the tobacco-insect investigations of the Bureau. The parasites emerged in due time, but through some defect in manipulation that may be remedied as a result of future work none of them could be induced to attack the native eggs.

EXPORTATIONS OF USEFUL INSECTS.

Prof. Antonio Berlese, of Florence, Italy, reports the continued spread of the American parasite of the mulberry scale and anticipates complete relief.

Exportations of American coccinellids have been made to Prof. F. Silvestri, of Portici, Italy, for the purpose of feeding upon this same scale insect. These coccinellids have been reared at Portici and have been liberated in mulberry groves at Acerra. The Chief of the Bureau, visiting in Italy in May, 1910, took with him a large box of these American coccinellids, which arrived at Portici in almost perfect condition, and from them Professor Silvestri expects excellent work.

Shipments of the parasite of the brown dog tick were made to officials in South Africa and to Italy.

WORK ON INSECTS AFFECTING SOUTHERN FIELD CROPS.

The work on insects affecting southern field crops deals with the following problems, in accordance with the classification made a year ago:

1. The cotton-boll weevil and other species injurious to cotton.
2. Insects injurious to tobacco.
3. Insects injurious to sugar cane and rice.
4. The Argentine ant.
5. Insects injurious to cacti utilized for food.

This work is conducted, under the direction of Mr. W. D. Hunter, by four trained assistants, located, in so far as possible, in the regions where the loss is greatest.

COTTON-BOLL WEEVIL INVESTIGATIONS.

The growing season of 1909 was very abnormal as regards damage by the boll weevil. Although the infested area increased as usual in the autumn, the damage in general was much less than is to be expected in a normal year. An unusually small number of weevils issued in the spring, owing to abnormal winter conditions. Unprecedented dryness, which began early in the spring, was continued throughout a large part of the growing season and checked rapidity of multiplication. Considerable damage, however, was done in

southern Texas and in the southern parishes of Louisiana. Considerable damage was done also in Mississippi. A conservative estimate of the loss will be about \$15,000,000.

On account of the obviously greater difficulty of the boll-weevil problem in the Mississippi Delta than elsewhere, as pointed out in previous reports, a well-equipped laboratory was started at Tallulah, La., where conditions characteristic of the whole delta region exist, and during the year substantial progress was made in the study of new means of control. Especial attention was paid to the possibility of utilizing parasites of the boll weevil. On account of the scarcity of material for breeding parasites in Texas it was impossible to carry the work as far as was desired. Nevertheless some practical indications of success have been obtained.

An important series of experiments was begun to determine the proper spacing of cotton plants in the field in order to obtain the maximum benefits of the factors in the natural control of the pest, including the parasites. These plats were located at five points in Louisiana.

The chain cultivator, perfected by the Bureau, was tested with especial reference to its adaptability to the peculiar soil conditions of the delta, and a study was made of the possibility of flooding the fields to kill the weevils in their hibernating quarters. This method will probably be practicable in some localities.

In connection with the utilization of the parasites of the weevil a study was made of the relative abundance of the flow of nectar with the different varieties of the cotton plant. This nectar furnishes the only food, so far as known, of the adult parasites. Therefore the cotton varieties that secrete the most nectar may be supposed to attract the parasites which will destroy the weevils. Also the cotton varieties which hold the squares best have been found to be more heavily parasitized than other varieties of cotton plants. Therefore a study of varieties having this habit has been carried on.

Extensive experiments were made in the effort to obtain definite knowledge regarding the hibernation of the weevil in the delta. The results obtained from these experiments will indicate the best time to take the greatest step in the control of the boll weevil, namely, the destruction of the cotton stalks in the fall.

Efforts were made also to ascertain the exact effects of excessive moisture on the hibernating insects, since it has been suggested that the heavy precipitation in the delta region may be unfavorable to the weevil during the hibernation period.

On account of the apparent success of experiments made by the Louisiana state crop pest commission with powdered arsenate of lead, experimental work in this direction has been carried on by the Bureau. Arsenate of lead is a very finely divided powder, and will reach parts of the plants that can not be reached by Paris green or other compounds hitherto used. An effort was made to ascertain how many applications are most profitable and the proper interval between applications. The experience of practical planters in using the poison has been collated. Work of this character was also begun in Texas. An important objection against the use of arsenate of lead is its high price, and, moreover, recent experiments seem to indicate that its effect upon the soil under some conditions may be very deleterious. The Texas experiments include a study of arsenical

and other poisons made up especially by certain manufacturers in the hope of discovering a cheaper compound and one which at the same time will possibly have less direct injurious effects upon the soil.

TOBACCO-INSECT INVESTIGATIONS.

The section of the southern field-crop insect investigations dealing with tobacco insects had its headquarters, as last year, in Clarksville, Tenn., and the work dealt largely with the control of the two species of hornworms of tobacco. An important addition was made to the knowledge of the life history of the hornworms. It was found that the emergence of the moths from the ground in the spring extends over a long period—in fact, until August. It has been supposed that the moths appearing in August were of the second generation, and hence it was argued that large numbers of the first generation of the worms must have escaped destruction by the poisons used. It was thought by planters that it would do little good to attempt to destroy the insects in hibernation, because a large number of worms would escape on young tobacco and in the next generation cause the so-called “August shower of worms.” It was found that a comparatively small percentage of the overwintering insects emerge before the end of June—in fact, in 1909 only 4 per cent issued before this time. The last individuals emerging produce a generation of such numbers as to injure tobacco seriously by August 1. During the eleven days from July 30 to August 9, 50 per cent of the hibernating pupæ became adult, and about 8 per cent became adult later. This emphasizes greatly the importance of taking all possible means toward the destruction of the hibernating forms—a move which the planters have hitherto been disinclined to make.

The usual means of controlling the hornworm has been the use of Paris green, but this poison is objectionable on account of injury to the leaf. Arsenate of lead, which does not injure the leaf, kills the insects so slowly that it is objectionable. A form of arsenate of lead has been found, however, which has not this disadvantage, and experiments were conducted with a number of other poisons which promise to be of practical value.

Experimental work against the tobacco flea-beetle was continued, in the way of application of sprays and dust in the plant beds, the dipping of the plants at the time of transplanting, and the application of various poisons both in dust and spray form to plants in the field. The improvement of the seed beds to avoid attack was also studied.

Further investigations on the so-called wireworm of tobacco were carried on at Appomattox, Va. It was found that the insect occurs in great numbers on several wild plants, but the great majority on two species which grow in fallow fields and waste places. It seems obvious that the elimination of these two weeds by cultural process or otherwise would go far toward reducing the injury to tobacco. The greatest damage was found where tobacco was planted on fields in which these weeds had occurred in the greatest numbers. Rotation, therefore, and the keeping down of weeds promise good results.

Further work has been done upon the tobacco thrips and the splitworm in Florida, but it was impossible to conduct this work continuously.

The work on the cigarette beetle, an important pest in tobacco warehouses, mentioned in the last report, was continued. Consideration has been given to fumigation with different gases at different temperatures, and an effort was made toward devising a new form of package for tobacco that would prevent the entrance of the pest.

SUGAR-CANE AND RICE INSECT INVESTIGATIONS.

The investigations of sugar-cane and rice insects, commencing July 1, 1909, consisted mainly of a preliminary survey of the species affecting these crops, and the beginning of work on the more important enemies that were found. The sugar-cane areas of Louisiana, Texas, and Florida were visited, as well as the rice-growing regions in Louisiana, Texas, and Arkansas. A laboratory was established in Louisiana, and quarters were provided by the Louisiana sugar experiment station, at Audubon Park. The Bureau has been fortunate in enlisting the active cooperation of the Louisiana state experiment stations in this work. This laboratory will be the headquarters for the sugar-cane and rice insect investigations for the South generally, and, as regards Louisiana, will be in direct cooperation with the state officials. The results of the work at this laboratory will apply in a general way to the areas in the entire sugar-cane and rice belts, with the exception of the sugar-cane areas in the Rio Grande Valley in southern Texas and those in southern Florida. Because of the open winters in these districts, by which the insect pests are able to develop continuously, particular consideration must be given to special methods of control.

Work was begun upon the sugar-cane stalk borer, the root beetle, the sugar-cane mealy bug, and the root weevil or maggot of rice. It is estimated that the annual loss through insect pests on sugar plantations in Louisiana reaches \$1,500,000; in the Rio Grande Valley the percentage of loss from the sugar-cane stalk-borer is probably as high, and the annual loss from insects injurious to rice in Louisiana, Texas, and Arkansas is estimated to be \$966,000. These figures will illustrate the importance of these investigations.

ARGENTINE ANT INVESTIGATIONS.

At the beginning of the fiscal year work on the Argentine ant was undertaken. Mr. Wilmon Newell, formerly secretary of the state crop pest commission of Louisiana, who had done the principal work upon this species in this country, consented to collaborate in this work, and an expert agent was appointed and placed at Baton Rouge, La. The main line of investigation was the relation between the ant and the sugar-cane mealy bug, the control of which seems to be complicated by the ant. At the same time efforts were made toward obtaining information regarding other features of the injury by the ant. The insect is of such importance in so many different ways that its life history must be investigated from every standpoint. Aside from this life-history work, experiments were begun in orange groves in lower Louisiana in the effort to control it by means of traps and the flooding process. This ant has threatened to destroy the orange industry in the parishes of lower Louisiana. In fact, many of the groves have been abandoned. The trap and flooding experiments

were very encouraging, and it is believed that a practical method of control can be perfected. Attention was also given to the question of preventing the spread of the ant in the United States.

OTHER WORK.

During the year as much attention as possible was paid to the cotton red spider in South Carolina and other States. It appears that this is a pest of more than local importance. Moreover, it is especially important to devise means of reducing injury by the red spider, on account of the invasion by the cotton-boll weevil which will take place before many years have passed. An agent was placed in South Carolina in the fall and in the spring, and experimental work was begun which will be carried through the coming year. The principal hope seems to be for cultural methods, the perfection of which will require some little time.

The investigation of insects injurious to cultivated cactus was practically completed during the year. A few observations and experiments must be repeated on account of the unusual weather conditions of the last year. In several cases good methods of control have been found. Insects interfering with the development of cactus as a farm crop will probably be controlled as a result of this investigation.

INVESTIGATIONS OF INSECTS DAMAGING FORESTS AND FOREST PRODUCTS.

In the course of the Bureau work on forest insects, Dr. A. D. Hopkins in charge, investigations of special problems have been carried on by experts and agents in Colorado, Montana, Oregon, West Virginia, Virginia, Maryland, New York, New Jersey, South Dakota, and Ohio. Information has been given to correspondents in nearly all of the States and Territories, and to forest officials in 62 national forests. Cooperation in the inauguration and demonstration of practical control has been carried on with the Forest Service in certain of the national forests of Colorado, Montana, and Oregon, with the Department of the Interior in a national park, on the public domain in Montana, and with private owners of timber in Montana, Washington, and Oregon; also with manufacturers of agricultural implements, machinery, and vehicles in Ohio, Indiana, and Illinois, and with the state entomologist in a forest insect survey of Illinois.

PRINCIPAL DEPREDACTIONS.

The principal depredations during the year have been the continued and extensive damage to living timber in the Rocky Mountain and Pacific slope regions by the Black Hills beetle and the mountain pine beetle on the pine, by the Engelmann spruce beetle on the spruce, and by the Douglas fir beetle on the Douglas fir. An enormous amount of choice timber has been killed during the year, and a threatened destruction of the larger trees in whole forests in Montana, Idaho, Washington, California, and Colorado can only be avoided by prompt and radical action by the Government, state officials, and private owners. Damage to the wood of important hardwood timber in the forests east of the Mississippi River has continued practically

unchecked, and is probably on the increase, owing to the present methods of lumbering and general management of forest land.

PRACTICAL APPLICATIONS AND RESULTS.

While there is evidence that some of the information on practical methods of preventing losses is being utilized to the best advantage to reduce the cost and increase the profits to owners and operators, which will ultimately lead to reduced cost to the consumer and the better protection of the resources, it becomes more and more apparent that, in order to convince the majority of the people who would derive the most benefit that the information is of real practical value to them, they must be shown. They either have not read the publications or asked for information, or they have not appreciated the importance of adhering to the essential details of the recommendations. Therefore, it has been necessary to carry on a certain amount of demonstration work and for the experts to give direct instructions and advice in the field.

This line of educational work carried on during the past four years has shown most gratifying results during the past year, especially in proving that the methods recommended may be easily understood and properly applied by owners of timber, government forest officials, and managers of manufacturing enterprises, and that the desired results can be secured through the proper expenditure of a comparatively small amount of money and energy.

The areas in Colorado in the vicinity of Colorado Springs, Palmer Lake, Idaho Springs, and on the Trinchera estate and Las Animas National Forest, where the control work directed against the Black Hills beetle was completed at various times since 1905, as mentioned in preceding reports, have been examined during the past year, and, as indicated by the failure to find dying or infested trees, the successful control work continues to have its protective influence.

The control work against the Black Hills beetle in the Wet Mountains section of the San Isabel National Forest, Colorado, completed at the close of the fiscal year 1909, was found, upon examination during the present year, to be a complete success, as were also the control operations in and adjacent to the Jefferson National Forest, Montana, which were started in June, 1909, and completed in July of the same year.

The evidence gathered from the results of the investigations and control work relating to these six cases indicates that the proper disposal of a total of some 4,000 trees within the areas during a period of four years at a first cost of about \$2,000, or an average of 50 cents per tree, has ended depredations, which, during a preceding period of ten years, had caused an average death rate of more than 7,000 trees per year, or a total of 7,000,000 feet, board measure, having a stumpage value of \$14,000.

The work carried on in cooperation with private timber owners and forest officials in northwestern Montana, inaugurated last fall, has yielded most satisfactory results, especially in the fact that the private owners have been made to realize the importance of prompt action to prevent the total destruction of the remaining merchantable timber. This has led to the proper treatment by cutting and barking or otherwise disposing of between 9,000 and 10,000 beetle-infested

trees by ten or more of the owners. This, it is believed, will be sufficient to control the depredations over an area of more than 100 square miles in which the timber has been dying at an alarming rate during the past ten or fifteen years. It will also have a marked effect toward protecting the timber of the adjacent areas of the national forests in which like depredations have been going on. The Department of the Interior has allotted sufficient money to take the immediate action required to control the depredations in the southwestern section of the recently established Glacier National Park. It is expected that the Forest Service will take the necessary action within the Flathead and Blackfoot National Forests during the coming year to dispose of a sufficient amount of beetle-infested timber, in addition to that disposed of by private owners and the Department of the Interior, to effectually check the depredations throughout the entire area, thus ending the losses of timber which have been progressing in this general region during the past ten years at a death rate of at least 200,000 trees annually.

IMPORTANT NEW WORK.

During the close of the year there has been organized the most extensive cooperative project for the control of barkbeetle depredations that has ever been undertaken in this country. It is designated as the Northeastern Oregon and Western Idaho Project and involves an area of over 13,000 square miles. The object is to undertake the control of the barkbeetle depredations on the living timber of the national forests and adjacent private and other lands through cooperation between the Bureau of Entomology, the Forest Service, and private owners. The plan provides that the experts of the Bureau of Entomology shall make the investigations of the insects, recommend methods of procedure in control work, and give special instructions and advice relating to the essential details, while the Forest Service and timber owners provide the funds required for the actual control operations.

The experts of the Bureau have already determined that the depredations are so extensive within the area and the time so limited before the beetles begin to emerge from the tens of thousands of infested trees to attack the living timber, that it is not practicable to undertake control work against the present (1909-10) infestation. It is believed, however, that the whole area can be sufficiently worked over and enough trees involved in the new (1910-11) infestation located, marked, and disposed of before the 1st of July, 1911, to effectually check, if not control, the depredations—thus preventing the further loss of timber which has been going on during the past five or six years at the estimated rate of nearly a million trees per year.

INVESTIGATIONS OF INSECTS DAMAGING DECIDUOUS FRUIT TREES.

The investigations of insects affecting deciduous fruits and vineyards, under the direction of Mr. A. L. Quaintance, have included the continuation of projects under way during 1909, and beginning with the spring of 1910 some additional lines of work have been taken up.

THE PEAR THRIPS.

The results of the Bureau's studies and experiments in the control of the very destructive enemy of deciduous fruits in California known as the pear thrips were set forth in the last report. It was found possible to destroy a large percentage of the total thrips in a given orchard by spraying with a tobacco and distillate spray in the spring, before the opening of the blossoms. Excellent results were also obtained in the destruction of the helpless pupæ in the soil by deep plowing and cross plowing in the fall.

In the fall of 1909 special attention was given to demonstrating on a large scale the benefits of plowing in the control of this insect, and in the spring of 1910 spraying operations were carried out in several parts of the infested territory. The Bureau's agents had full charge of several orchards or parts of orchards, and in addition acted in a supervisory manner over the work done by a considerable number of orchardists. In this way a large amount of remedial work was accomplished, and the active interest of many orchardists in Santa Clara, Contra Costa, Solano, Sacramento, and other counties has materially strengthened the Bureau's work. Thus, in the territory adjacent to Walnut Creek there were sprayed about 220 acres of pears, 100 acres of prunes, and 30 acres of cherries; in the Suisun territory 200 acres of pears, 190 acres of cherries, and 60 acres of prunes; and in the Courtland district 200 acres of pears and 20 acres of cherries; a total in the district to the north of San Francisco of 620 acres of pears, 160 acres of prunes, and 240 acres of cherries.

In the Santa Clara Valley the Bureau's work proper included thorough plowing of about 100 acres and the spraying of about 70 acres of orchard. There were plowed, however, under the advice of the Bureau, about 1,650 acres, and in a similar manner 540 acres of orchard were sprayed. This work on the whole has yielded about as successful results as were obtained the year previous. However, the benefits have been somewhat obscured on account of the serious injury to the prune crop by late spring frost. There is, unfortunately, often a tendency on the part of orchardists to attribute to any injurious insects that may be present the losses resulting from unfavorable weather conditions. It is proposed to take the yield of fruit from sprayed and unsprayed blocks in the orchards under treatment and thus secure definite figures as to the benefits of the work which may be expressed in dollars and cents.

Along with the demonstration and experimental field work, a considerable number of other sprays have been tested as they were sent in by persons believing them to be of value or which have been made according to formulas suggested. None of these, however, has proven equal to the tobacco and distillate oil spray mentioned, and this has become the main reliance. Attention has also been given to obtaining additional information on various points in the life history of the insect, especially in orchards, as to its migration and ground habits, and its distribution in different types of soil. It seems possible that in the deeper alluvial soils, as in the Courtland district, the value of thorough plowing will be materially lessened for the reason that the larvæ are able to penetrate to a considerable depth and below the reach of plows. Our knowledge of the insect, however, is now very

complete and covers its behavior during the entire year. A complete report on the investigations in the field and laboratory during the past three years is now in course of preparation.

THE CODLING MOTH.

Studies of the codling moth on apple have been continued along lines previously reported. The experiments undertaken in the spring of 1909 in a comparison of the so-called one-spray method, in use in the Northwest, with the practice of spraying generally followed in the East, were concluded and a large amount of data on the subject accumulated, the results of which have already been submitted for publication. In general, it appears that about as good results may be obtained by the one-spray method, in so far as the control of the codling moth and curculio is concerned, as by several treatments applied in the customary way. Notwithstanding these results obtained by the one-spray method, however, the plan is not considered to be of special importance under eastern conditions, for the reason that in this territory it is necessary in nearly all cases to make several applications of a fungicide during the course of the season for the control of fungous diseases, and under these circumstances the addition of an arsenical is, of course, desirable. However, the work points out unmistakably the great importance of much more thorough spraying at the time of the falling of the petals and under a higher pressure than has generally been given heretofore. Further tests of the one-spray method are in progress in Virginia and Michigan, and it is hoped that a final report may be prepared at the close of the present season from the data secured.

The experiments in Missouri and Arkansas orchards in cooperation with the Bureau of Plant Industry of this Department, and mentioned in the last report, comprising a comparison of dusting versus spraying in the control of the codling moth, plum curculio, and fungous diseases, were concluded in the fall of 1909, and report upon the work is in preparation. It appears that the use of dust sprays for the codling moth, curculio, and other apple insects gave results very much inferior to those obtained by the use of liquid sprays, and the dust sprays are notably ineffective in the control of fungous diseases. Thus, in Missouri the yield of merchantable fruit from dusted plats was approximately 3 per cent of the crop as compared with 86 per cent of merchantable fruit on plats sprayed with Bordeaux mixture and arsenate of lead.

Life-history studies of the codling moth in important fruit regions are being continued as heretofore, as in California and Michigan. The studies in progress during the last two seasons in northwestern Pennsylvania have been completed and a report upon the work is now in press. This investigation brought out forcibly the influence of temperature on the extent of, and injury by, the larvæ of the second brood. Thus, during the season of 1907 the proportion of first-brood larvæ to transform into adults was 3 per cent, whereas during the season of 1908 the proportion transforming was 67.7 per cent, a difference due entirely, it is believed, to the widely different seasons which prevailed during these respective years. Similar studies have been made in the Ignacio Valley, in California, in connection with experiments for the control of the codling moth on

pears. Owing to a lower mean temperature in this valley than in many other fruit-growing regions, the period for the life cycle of the codling moth was greatly lengthened, requiring from sixty to seventy days, as compared with forty-nine to fifty-six, the time required in the East. Spraying experiments for the codling moth in the Ignacio Valley on pears were completed and gave very satisfactory results. Plats of trees receiving two and three applications of arsenate of lead in Bordeaux mixture gave, respectively, 87.68 per cent and 97.10 per cent of sound fruit, whereas on the unsprayed fruit trees only 46.85 per cent of the fruit was free from injury. There was a net gain in favor of spraying of \$1.49 per tree. A detailed report on the life history of the insect in the valley and the results of the experiments on pears has been submitted for publication.

Demonstration spraying for the codling moth is being continued during the season of 1910, as heretofore, in cooperation with the Bureau of Plant Industry, mostly in connection with other investigations at the several field laboratories. This work is in progress on pears in several localities in California and on apples in Michigan and Virginia and in nine counties in eastern Kansas in cooperation with the Kansas State Agricultural College. A detailed life-history study of the insect is also being made in the Santa Clara Valley. The demonstration spraying under way in Virginia, Arkansas, Pennsylvania, and Michigan during 1909 was successfully completed and gave uniformly good results. This work has been most heartily appreciated by orchardists in the respective neighborhoods and seems worthy of further extension.

THE GRAPE ROOT-WORM.

The investigations of the grape root-worm, which have been in progress since 1907, were continued over the growing season of 1909 as outlined in the report for that year. This investigation has been very thorough both in the field and in the laboratory, and entirely practical and economical measures have been fully demonstrated. The work was therefore practically concluded in the fall of 1909 and a full report has been submitted for publication.

MISCELLANEOUS GRAPE INSECTS.

In the course of the work on the grape root-worm much information was accumulated on other grape insects. It was found that some of these were of considerable importance, and upon the closing of the grape root-worm studies specific attention has been directed to the so-called rose bug and the grape leafhopper in the Erie grape belt. Studies are also being made on a new insect enemy of the grape, namely the grape bud gnat, which is assuming more and more importance as an enemy of this crop.

ARSENIC ACCUMULATION IN SOILS IN SPRAYED WOODLANDS, ORCHARDS, AND VINEYARDS.

The agitation concerning the danger of injury to orchard, shade, and other trees by excessive spraying with arsenicals, especially with arsenate of lead, led to an examination of soils in sprayed orchards, woodlands, etc., to determine if there were possibly an accumulation

of arsenic in the soil, and an examination also of trees which might be injured from this cause. A large number of samples was collected during the summer of 1909, and these have been examined by the Bureau of Chemistry, in cooperation with which Bureau the work is being done. The examination of these soils has shown the necessity for further studies and an additional series of soil samples will be collected from the same territory as those earlier obtained.

INSECTICIDE INVESTIGATIONS.

Further experiments have been made with lime-sulphur washes, especially when used with various arsenicals. Special attention is being given to determine the effects of a combined lime-sulphur and arsenical spray on peach foliage, including the various brands of arsenate of lead and other poisons, such as arsenic sulphids, arsenate of iron, zinc arsenate, etc. In California much attention has been given to the preparation of various sprays, especially emulsions of crude oil and distillate, in the course of experiments against the European pear scale and the European fruit Lecanium, or, as it is better known, the brown apricot scale.

DEMONSTRATION SPRAYING FOR THE PLUM CURCULIO.

The plum curculio in the South is a veritable scourge to the peach growers, every year greatly curtailing the crop, its punctures in the fruit, moreover, forming a nidus for brown-rot spores, greatly favoring infection from this serious fruit disease. So critical had become the situation due to the losses from these two troubles—the curculio and the brown rot—that the assistance of the Department was asked through the Georgia Fruit Growers' Exchange, and also by numerous large commercial orchardists. In cooperation with the Bureau of Plant Industry, demonstration spraying on a large scale was begun in different parts of Georgia, using arsenate of lead and self-boiled lime-sulphur mixture as a combined treatment for the curculio and brown rot and the scab. The scheme of treatment requires three applications in all, which practice it had previously been determined would effect the control of the several troubles. In addition to the work under the direct supervision of the Department a very large number of orchardists, acting under its advice, has adopted the plan of spraying recommended, and the total trees treated during the spring of 1910 aggregated several hundred thousands. This work is conducted on a strictly commercial basis, careful account being kept of the cost of the work, and the benefits will be accurately determined by a comparison of the fruit on sprayed and unsprayed blocks.

CRANBERRY INSECT INVESTIGATIONS.

The studies of cranberry insects in Wisconsin, in cooperation with the university of that State, mentioned in earlier reports, were continued along the lines indicated during the season of 1909, and beginning with the spring of 1910 demonstration spraying has been inaugurated in cooperation with numerous cranberry growers, who bear all costs of the work except for spray materials. An unusually

complete survey of injurious insects of the cranberry bogs in Wisconsin has been about completed, and a good knowledge of the life history of most of these has been obtained. These studies have been made on the bogs under perfectly natural conditions and will be of the utmost value as a basis for making recommendations for their control. Spraying operations under way in 1909 were carried through the season and the results recorded in a way to show the benefits in dollars and cents. The general absence of the fruit-worm, which had been very destructive the year previous, however, resulted in less marked benefits than previously obtained; nevertheless, the results from spraying showed a considerable improvement over unsprayed plats. This work will be concluded at the close of the present season, and it is planned to extend it to cranberry bogs in other States.

CEREAL AND FORAGE-PLANT INSECT INVESTIGATIONS.

Several new problems have engaged the attention of the cereal and forage insect section of the Bureau, under the charge of Mr. F. M. Webster, and the older investigations have been continued.

THE SO-CALLED "GREEN BUG."

The spring grain-aphis, or so-called "green bug," has continued to claim attention. During the autumn of 1909 it seemed to have reached its usual abundance along the line extending from North Carolina to New Mexico, but the ensuing winter was normally cold and restrained the pest, while in March there was an extraordinarily high temperature which enabled the parasites to develop in the spring, so that the pest was soon overcome by its natural enemies. The reverse of this—that is to say, a warm winter and a cold spring—would have certainly produced an enormous abundance of the insect. This emphasizes more than ever the imperative necessity for continuing government surveillance over the region where this pest first begins its depredations in the spring. This area covers approximately 13 States and Territories, while the territory now known to be occupied by the species, and therefore more or less threatened, covers approximately the whole United States west of about the latitude of the city of Washington, excepting perhaps in extreme western New York and Pennsylvania. At present it seems possible to diagnose the situation by keeping close watch upon the species throughout the area where it first begins its ravages, and by utilizing the records of the Weather Bureau. The studies of the past year emphasize the statement previously made that an outbreak of this pest depends upon temperature conditions beginning in the South, and the extent of its ravages depends wholly upon weather conditions during winter and spring. It seems, therefore, extremely desirable that there should always be a sum available for this particular investigation.

A complete report on this insect and its parasites will be prepared for publication during the fiscal year 1911.

WORK ON THE JOINTWORM.

The investigation of the jointworm has been continued more particularly throughout Ohio, Indiana, and southern Illinois, but the insect has been found injurious for the first time in the wheat in Mis-

souri. Curiously enough, another problem has entered into the jointworm investigation, which involves sanitary as well as agricultural matters. A mite known as *Pediculoides ventricosus* attacks both the jointworm and its hymenopterous parasites, and by its work upon the parasites prevents them from overcoming the jointworm. The mite remains in the straw up to and during the early summer following the harvest, and, whether this straw goes into the manufacture of mattresses or whether it enters into the domestic economy of the farm, it invariably causes a very annoying skin disorder, recently designated by Doctor Goldberger as *Dermatitis schambergi*. Throughout the Middle West the jointworm is the host of this mite, but the mite has caused equally serious trouble in eastern Pennsylvania, New Jersey, Delaware, Maryland, and Tennessee. Throughout this last territory the host insect is the Angoumois grain moth. In both cases it appears that a revision of certain agricultural methods will become necessary. The farmer throughout the Middle West and in the East draws the unthrashed grain in from the fields, places it in barns, and allows it to remain unthrashed for weeks, and sometimes perhaps even for months. This facilitates the development and increase of the mite, and causes an increased number of cases of dermatitis. In Tennessee the farmers allow the grain to remain in the shock long after it should have been thrashed. This also facilitates the increase of the mite, with the result that when this grain is thrashed the men and teams engaged in the work are attacked and caused great pain and suffering. In all cases, if the wheat is thrashed directly from the field and as soon after harvest as it is in condition for thrashing much of the difficulty will be overcome.

HESSIAN FLY INVESTIGATIONS.

The investigations of the Hessian fly have been continued, and a successful introduction of parasites from Kansas has been made into the wheat section of western Oregon. It now seems quite possible as the result of the investigations of the year that what was supposed to be winter-killed wheat in Oregon has really been the work of the Hessian fly. In recent years farmers have found it impracticable to grow wheat in western Washington and Oregon on this account. The attacks of the Hessian fly in the fall have produced this result, and the successful introduction of eastern parasites should have a beneficial effect.

An unexpected outbreak of the Hessian fly in Tennessee is being investigated in cooperation with the agricultural experiment station of that State.

Up to the present time it has been impossible to secure absolute proof that the Hessian fly will attack grasses, but it has been ascertained during the year that it attacks one or more species of *Agropyron* both in Kansas and in western Washington. To what extent this phase of the problem will increase in the future it is impossible to predict, but it will have the effect of allowing parasites to breed in grass affected by the Hessian fly and to migrate to wheat fields and attack the host insect there.

THE NEW MEXICO RANGE CATERPILLAR.

The unusual and serious state of affairs caused in northeastern New Mexico by the sudden extraordinary development of the larva

of a large moth attacking the gramma grass on cattle ranges was referred to in the last report. An expert assistant devoted a large portion of the fiscal year to an investigation of this outbreak, and the results have been published in Part V of Bulletin 85 of the Bureau. The insect has spread from a limited area in northeastern New Mexico into the Panhandle region of Texas and the Cherokee strip of Oklahoma, as well as into adjacent portions of Kansas and Colorado. Owing to the immense territory covered by the insect, and to the topography of the country, some of which is almost inaccessible, applications usually employed for destroying insects are impracticable. Only a very small percentage of the caterpillars are parasitized, and yet, from the present outlook, the introduction of parasitic enemies seems the only remedy.

THE ALFALFA WEEVIL.

The alfalfa weevil, beginning in the region about Salt Lake City, is apparently an introduced European insect. It was first observed in the vicinity of Salt Lake, not far from nurseries importing more or less stock from southern Europe, thus indicating a possibility of its introduction in the packing of stock. At the end of the fiscal year 1910 it was making rapid headway toward the alfalfa fields of Colorado, Wyoming, and Idaho. It constitutes a great menace to alfalfa culture. Studies of the life history of the weevil have been carried on in cooperation with the Utah agricultural experiment station, and experimental work has been done with remedies. The peculiar life history of the insect, however, which lays its eggs during a period of six weeks in the spring, near the base of the plant, renders operations against the larvæ extremely onerous on account of the necessity of frequent repetition. An experiment was made in the introduction of a fungous disease which kills an allied weevil in the Atlantic States, but without success. Possibly in irrigated regions with the proper moisture conditions this disease may be made to take hold.

THE SORGHUM MIDGE.

The sorghum midge, which prevents the sorghum raisers in the far South from securing seed, has been thoroughly investigated, and the results have been published. It now seems as though a large part of the difficulty experienced will be eliminated by the destruction of trash left in the field and of the Johnson grass escaped from cultivation and growing along roadsides and other waste places.

OTHER INVESTIGATIONS.

The other investigations of this branch of the Bureau work have included a study of the wheat strawworm in Kansas and the extreme Northwest, the corn root-aphis, the cowpea curculio, the slender seed-corn ground-beetle, a butterfly larva damaging alfalfa in California, Arizona, and Nevada, a gall fly attacking the seed pods of alfalfa in Arizona, the southern corn leaf-beetle, the southern corn root-worm, wireworms, and a number of other species. An important investigation has also been carried out regarding the exact relations of leaf-hoppers to the cultivation of grains and grasses. It was shown some

years ago by Prof. Herbert Osborn, of the Ohio State University, that the productiveness of pastures is very greatly reduced by these insects, and it is hoped by this investigation to ascertain facts which will bring about amelioration.

WORK ON INSECTS AFFECTING VEGETABLE CROPS.

Work against insects affecting vegetable crops has been carried on, as during the last two years, in different parts of the country. The work has been both demonstrational and investigational. As pointed out in the report for 1908, although the insects occurring in these different regions are frequently identical, their habits and life histories differ on account of the difference in climate, and require either different remedies or modifications of the same remedy. The work has been carried on as heretofore under the direction of Dr. F. H. Chittenden. It is estimated that the annual loss in a number of the most important truck-growing regions of the country from insect damage is 20 per cent of the crop, and that the preventable injury is about 15 per cent, thus indicating the value of the most up-to-date knowledge in this direction.

INVESTIGATIONS IN TIDEWATER VIRGINIA.

Investigations reported upon in the last annual report, in cooperation with the Virginia truck experiment station, the Virginia department of agriculture and immigration, and with associations of truck growers of Norfolk, Va., and vicinity, have been continued. Much demonstration work was found necessary, but some important investigations have been carried on. It has been found that the pea aphid may be successfully controlled by spraying early in the season with whale-oil soap at the rate of 6 pounds to 50 gallons of water, three or four sprayings being necessary for the best results. Tests were made with different nicotine preparations against this same species. Experiments with a lime-sulphur-arsenate-of-lead mixture for the Colorado potato beetle were found quite effective, destroying fully 95 per cent of the insects by a single application. Experiments have been continued against the striped cucumber beetle, the best results being obtained with a combination of arsenate of lead, 3 pounds, in Bordeaux mixture, 2-5-50, as a spray. The strawberry leaf-roller has also been studied in this locality as well as certain other insects.

STRAWBERRY INSECT INVESTIGATIONS IN NORTH CAROLINA.

Beginning with March, 1910, an agent was stationed at Chadbourn, N. C., to study strawberry insects. In 1908 the strawberry weevil caused the destruction of 50 per cent of the strawberry crop in one locality in North Carolina, the cash loss being \$700,000. In 1909 the loss in the immediate vicinity of Chadbourn was estimated at \$150,000. Especial attention was given to the life history of the species in the locality mentioned. As a result of the preliminary study which has been given to this species and the tests of remedies thus far, it is the belief that the following four items of farm management will work well in keeping strawberry fields free from weevil attack:

1. Cultivation of a large acreage.

2. The destruction by burning of all adjacent undergrowth in the late fall or winter, and the removal of all wild food plants and débris in which the insects could find winter quarters.

3. High cultivation to secure a maximum number of buds.

4. Immediate and close cultivation of the beds after picking, to destroy infested buds.

The strawberry leaf-roller and a root-worm were also studied in this locality.

INVESTIGATIONS IN COLORADO.

At the beginning of the fiscal year work on truck-crop insects in Colorado was begun, with headquarters at Rocky Ford. The investigation was taken up in cooperation with the Rocky Ford Chamber of Commerce and the commissioners of Otero County and the Rocky Ford Melon Growers' Association. Work was continued until December 1, 1909, and resumed March 11, and continued to the end of the fiscal year 1910. A preliminary test was made of the trap-crop ladybird method of controlling the melon aphid, early growing crucifers being used as a trap crop. The species was largely controlled by natural enemies, so that slight damage was done.

The yellow bear caterpillar did much damage to sugar beets and to the truck crops of the upper Arkansas Valley. It was decided that the best method of controlling the pest was the cleaning up and burning of the rubbish in fence corners and similar places where the insect hibernates. In the same way the best remedy for the larger beet leaf-beetle, or "alkali bug," was found to consist in destroying heaps of weeds, tufts of grass, and other débris in which the insect passes the winter.

The red spider in its occurrence on celery, beans, and other plants, including shrubs, ornamental bushes, and trees, was readily controlled by the use of a lye-sulphur solution.

Further studies were made of other crop insects in this region.

TRUCK INSECTS IN MISSISSIPPI.

In the summer and fall of 1909 work was begun in the State of Mississippi against truck insects, with headquarters at Starkville. This work is still going on against the pests especially injurious to cabbage, Lima beans, melons, tomatoes, and strawberries.

IN CALIFORNIA.

An especial investigation of insects damaging sugar beets and truck crops has been carried on in this State with headquarters at Compton, and the life histories of the insects concerned have been studied and experimental work instituted.

IN SOUTHERN TEXAS.

The work at Brownsville, mentioned in previous reports, has been continued. The onion thrips, with the melon aphid, appears to be the most serious truck-crop pest of southern Texas, and as to the onion thrips the work so far done indicates that unless remedial measures, such as the changing of the farming methods or the appli-

cation of poisonous sprays, are undertaken, the cultivation of this important crop must be abandoned. The practice of growing onions by starting them in sets seems to be one of the chief causes of injury by thrips. Some injury may be prevented by dipping sets, before transplanting, in nicotine sulphate at about the same strength as used in spraying. Clean methods of cultivation, including prompt destruction of remnants, and the stimulation of plants by means of fertilizers and irrigation where possible, are among the best forms of farm procedure. In some localities the observance of these methods serves to hold the insect in check; in others it is also necessary to spray.

Reports upon a number of Texas insects belonging to this class have been submitted and accounts will be published.

OTHER INVESTIGATIONS ON TRUCK-CROP INSECTS.

The onion thrips just mentioned is by no means confined to Texas, but occurs also in Colorado, and recent reports of injury have been received from Stark County, Ind. The estimate of loss in the latter locality was \$30,000 for 1910 in the vicinity of the town of Knox alone. The same insect also occurs in the vicinity of the District of Columbia, and studies of its habits in this locality have been begun.

WORK ON INSECTS AFFECTING CITRUS FRUITS.

As during the previous year, the work on insects affecting citrus fruits has been carried on under the supervision of Mr. C. L. Marlatt. The principal items have been the continuation of the white-fly investigations, work upon the orange thrips in California, and the completion of the hydrocyanic-acid gas fumigation in California.

WORK ON THE WHITE FLY IN FLORIDA.

With the conclusion of the main features of the life-history studies and fumigation experiments on the white fly, summarized in previous reports, problems connected with insecticides and the mechanics of spraying as adapted to Florida conditions have been made the subject of especial study. The agents of the Bureau, however, have continued the very important experiments leading to natural control by bacteria and fungi, and have cooperated with growers in conducting fumigation on a large scale.

Experimental work and observations during previous years with parasitic fungi have demonstrated that under normal climatic and favorable grove conditions the fungi are capable of effecting in a series of years about one-third of a complete remedy, and that they can be very readily introduced artificially into groves infested with the white fly. The main line of investigation during the past year has been to determine to what extent the natural efficiency can be increased by frequent artificial introductions of spores by spraying at stated periods throughout the summer and early fall. This work has not given encouraging results. The amount of fungus present at the end of the season in no instance was enough greater than that developing under normal conditions in unsprayed surrounding trees to warrant from a practical standpoint the time expended in the

work. In several instances more fungus developed on unsprayed trees. Observations and experiments have led to the conclusion that losses resulting from the white fly attacks will be greatly reduced if, in the majority of cases, the parasitic fungi are disregarded and the use of direct remedial measures extended as fast as possible.

While no specific bacterial disease of the citrus white fly or spotted-wing white fly has yet been discovered, it became evident very early in the present investigation that mortality among larvæ and pupæ resulting from causes other than those recognized as attacks by insect and known fungus enemies, and from overcrowding, was the most important element of natural control affecting these species. This heretofore unappreciated check effected by nature has been credited to the fungi, greatly enhancing the value of the latter. In several instances the fungi have been credited with controlling the fly in groves in which none of the known fungi was present, or in which they were present in too small numbers to bring about the great reduction in the numbers of flies. This phase of natural control is still under investigation.

Fumigation experiments were conducted only in cooperation with the Tangerine Citrus Association of Tangerine and the growers of Arcadia. In each instance an agent of the Bureau gave assistance in securing the necessary apparatus and chemicals and in the general methods of procedure. The fumigation of over one thousand trees under varying conditions thoroughly demonstrated the value of the method of control in isolated groves, as well as its uselessness in groves closely surrounded by untreated infested groves.

The experimental work of the previous year to determine the cost and effect of various insecticides has been continued, together with an extensive study of the mechanics of spraying as adapted to the peculiar conditions presented by the problem in hand. It has been found that by a careful application of knowledge gained by life-history studies the cost of insecticides can be reduced about two-thirds during late spray; while experiments have shown that their cost can be safely reduced about one-half during the summer months, due to the greater susceptibility of the larvæ and pupæ at this season. The control of the fly by spraying has been undertaken in several groves, consisting of several thousands of trees of all sizes, and data are accumulating to warrant the statement that spraying, when once given an intelligent continued trial, will be found a much more promising method of control than is generally believed.

THE ORANGE THRIPS.

The orange thrips, a serious insect enemy of orange in the southern San Joaquin Valley in California, has been under investigation for about two years, and most gratifying progress has been made in the determination of control measures. Large-scale experiments with various sprays have been continued, and on the whole the pest has proved to be less resistant to the sprays than was found to be true of its near relative, the pear thrips. Two or three applications, however, appear to be necessary, since there is a series of generations occurring during the year. The actual area of orange groves under experiment by the Bureau in 1910 is approximately 30 acres, the growers cooperating in allowing the use of the trees. The destructiveness of

the insect and the successful results obtained by sprays have resulted in a very active interest on the part of orchardists themselves, and a large number of power sprayers have been purchased and extensive spraying operations begun under the advice and immediate supervision of agents of the Bureau. The total area of orange groves treated for the orange thrips during the spring of 1910 is approximately 2,000 acres. This is the more remarkable when it is remembered that previous to the spring of 1909 practically no spraying whatever was practiced.

INVESTIGATION OF HYDROCYANIC-ACID GAS FUMIGATION IN CALIFORNIA.

The investigation of hydrocyanic-acid gas fumigation in California, taken up at the beginning of the fiscal year ending June 30, 1908, was completed with the close of the fiscal year ending June 30, 1910. The same character of field work has been continued throughout, and efforts were made to conduct the investigation on as nearly a commercial scale as possible, so that conditions and results would be those normal to the ordinary care of citrus groves. The results, which have been brought together in the form of a bulletin about to be published, have been very satisfactory. The orange growers expressed themselves as pleased, and the expense of the operation has been very considerably reduced, and, as a result of the efficiency obtained, longer intervals between fumigations will now serve to keep the groves in good condition. Important experiments have been conducted with sodium cyanide, and it has been found that with the use of a high-grade sodium cyanide the results are as satisfactory as with a high-grade potassium cyanide. When it is considered that the present manufacture of sodium cyanide is more universal and greatly in excess of potassium cyanide; that the sodium compounds required in the manufacture of sodium cyanide are widely distributed throughout the world, while commercial deposits of potassium compounds required in the manufacture of potassium cyanide are largely confined to the German Empire, and also that the present unit price of sodium cyanide averages slightly less than that of the other, it may reasonably be expected that in the future the sodium may be found supplanting potassium in American usage.

The field laboratory at Whittier, Cal., used in these investigations, was abandoned June 30, when the lease expired, and the apparatus was turned over to the Bureau. The agent in charge, Mr. R. S. Woglum, was transferred to another investigation.

INVESTIGATIONS OF INSECTS IN THEIR DIRECT RELATION TO THE HEALTH OF MAN AND DOMESTIC ANIMALS.

One of the most interesting investigations under the branch of the Bureau work dealing with insects in their direct relation to the health of man and domestic animals has already been mentioned in this report in the earlier section on "Work on the jointworm." As the jointworm is a host of the mite in question, it is considered in full in that section rather than here.

The subject of remedies and preventive measures for mosquitoes has been considered at great length in a bulletin published in the spring of 1910 (No. 88), and the whole ground has been rather thor-

oughly covered. It is hoped to follow this bulletin on the active remedial work with others treating of malaria and the malarial mosquitoes, of yellow fever and the yellow-fever mosquito, of the general habits of mosquitoes, and still another on the classification of mosquitoes.

THE HOUSE FLY.

The work on the house fly has been continued, and the crusade against this disease-bearing species has been assisted in every possible way. The name, suggested by the writer, of "typhoid fly" as a substitute for the name "house fly" is becoming generally adopted. Conservative physicians appear to be more and more convinced of the dangerous qualities of this insect. The American Civic Association has taken up the crusade, and boards of health and citizens' improvement societies all over the United States are paying great attention to the destruction of this species. The crusade has extended into other countries, and the Bureau congratulates itself on having at last aroused strong public opinion in a very important sanitary matter.

WORK ON TICKS.

The work of the Bureau on the important injurious ticks of the country has been conducted under the direction of Mr. W. D. Hunter by Mr. F. C. Bishopp. These investigations have consisted of two primary lines of work: First, with the tick which transmits splenic fever of cattle, and, second, with the species *Dermacentor venustus*, which transmits spotted fever of human beings in some of the Rocky Mountain States.

The work on the cattle tick consisted of two parts, one dealing with the continuation of life-history studies and the other with practical demonstrations of methods of control for the benefit of ranchmen. The great diversity of climatic and other conditions in the area infested by the cattle tick causes it to be exceedingly important to ascertain the local variation in the development and life history of the pest. Moreover, such definite information must be available for the practical work of eradication which has been undertaken by the Bureau of Animal Industry and can only be obtained by means of experiments running through several years. Consequently, the experiments to determine the length of time the seed ticks can survive without hosts were continued. Special efforts were made to secure records from a number of localities. In this work the Tennessee experiment station cooperated in a very helpful manner.

On account of the general popular idea that sulphur taken into the system of cattle either by feeding or drinking of water impregnated with the substance will cause the ticks to drop off, a special experiment was arranged to furnish exact information. A fence was built around a well in southern Texas, the water from which is very heavily impregnated with sulphur. Small droves of cattle heavily infested with ticks were placed in this inclosure from time to time and observations were made regarding the action of the ticks. The results were entirely negative. The well used in the experiment represents extreme conditions as regards sulphur content. The results, therefore, are of very definite value and should prevent the useless expenditure of money for sulphur on the part of cattle owners.

Two large demonstration pastures in southern Texas, one in Victoria County and one in Calhoun County, were utilized for the purpose of demonstrating the feasibility of reducing the tick infestation to a practically negligible quantity. Cattle were removed from these pastures in the spring and returned in the fall. It was found in both pastures that the cattle were practically free from ticks in the spring, although the cattle which had been pastured elsewhere were heavily infested. In the demonstration pastures a continuous and very profitable gain in weight was made and in the others the cattle were in such condition from tick infestation that very low prices were secured.

Efforts to cause the parasite of the brown dog tick to attack the cattle tick were continued but without definite results, except as to methods of manipulation that will assist in future work. Shipments of the parasites were made to South Africa and Italy for attempted introduction by the government entomologists.

Progress was made in the work on the species of ticks which transmit spotted fever of human beings. An agent traveled through some of the Northwestern States to obtain material to reveal the distribution of the species. This work will result in an exact knowledge of the geography of the disease, or at least the region in which it can spread if once introduced. Following this preliminary work, a camp laboratory was established in the Bitter Root Valley, in Montana, where a very virulent phase of the disease exists. Through this laboratory a study was made of the distribution of the dangerous ticks in the locality. There are many points that need investigation. For instance, the disease occurs commonly on the west side of the valley but rarely on the east side. This phenomenon is probably due to some limitation in the distribution of the ticks. In addition, studies of the life history, habits, and means of control will be conducted and demonstrations will be inaugurated if the investigational work seems to warrant it. This work is in cooperation with the Montana State University and the Montana board of health. Prof. R. A. Cooley, of the university, has become a collaborator of the Bureau, and is directing the work. On account of his extensive study of the problem it is considered that the Bureau is fortunate in being able to perfect this arrangement. One of Professor Cooley's students is stationed at the camp. The Biological Survey of the Department is also cooperating. It has stationed two men in the field to determine the limitations in the range of the various animals which act as hosts for the ticks. The Montana board of health has agreed to place a physician at the camp. The work is therefore organized in a comprehensive way and should yield important results.

In addition to the work in the Bitter Root Valley a large amount of information concerning the distribution of the ticks throughout the Rocky Mountains region was obtained by means of circulars. In this way over 500 lots of ticks were obtained, representing practically as many localities. This will enable the Bureau to map the distribution of the form which is now known to be pathogenic in nature and of others which may later be found to be capable of transmitting diseases.

In addition to the main lines of work indicated, progress has been made in the study of some of the other important ticks. A number

of experiments with the fowl tick have been conducted. This form is so injurious that it has caused the abandonment of the poultry industry in some places. The work has been carried far enough to result in practical suggestions for control which will be dealt with in a circular soon to be issued.

There is a possibility that destructive ticks may be introduced into this country from Mexico at any time. They might be brought across the boundary on cattle, horses, dogs, or even human beings. In order to determine the actual danger an agent was sent through northern Mexico for a few weeks during the year. The results indicate that precautions against the entrance of new forms should by all means be taken.

WORK ON INSECTS INJURIOUS TO STORED PRODUCTS.

The work on insects injurious to stored products has been continued along similar lines, under the direction of Dr. F. H. Chittenden. Special attention was given to inspection and fumigation, as demonstration work and as experiment, in mills in Kansas, Texas, Oklahoma, Missouri, and Louisiana.

THE POINT OF INFESTATION TO EXPORT FLOUR.

The original source of the trouble which caused requests for this line of investigation was the infestation, chiefly by flour beetles (*Tribolium ferrugineum* and others), of export flour milled in the States mentioned and shipped to Europe and Africa, mainly through the ports of New Orleans and Galveston. During the two years in which this topic has been under constant investigation, in the warmer months which permit of such work, effort has been made to determine the exact point of infestation, which might be at any place—at the mill or between that point and the place where the flour is delivered to the purchaser. While a possibility exists of infestation on car and steamship lines, on wagons used in carting the flour or other cereal from the mills to the port of destination, and at the ports both in this country and abroad, it is now established that in the vast majority of cases the point of primary infestation is the milling establishments themselves. A large number of mills have been investigated in the States mentioned, and while many are maintained in a scrupulously neat and clean manner and are fumigated twice a year, or as often as necessary, still there are many others where carelessness prevails and where fumigation is not regularly performed. In the carelessly kept mills, flour beetles, the Mediterranean flour moth, and various other mill pests accumulate and are carried from the mills on sacks of flour, thus infesting cargoes which reach foreign ports in unsalable condition. Under conditions favorable to their development, in warm weather, some of the insects can develop from egg to adult in five or six weeks.

THE MEDITERRANEAN FLOUR MOTH.

As in the past year, the Mediterranean flour moth has again engaged the largest share of attention. The larva or caterpillar of this species is the greatest pest with which millers have ever had to con-

tend. It particularly infests the machinery of mills, spinning a web which causes flour to become felted and lumpy, and, in summer weather, this clogs the machinery, necessitating frequent and prolonged "shut-downs" resulting in the loss, in large establishments, of thousands of dollars. The average cash loss due to closing a mill and the cost of treatment by fumigation and cleaning has been estimated at about \$500 for each fumigation, excluding the loss to business, while the owners of mills of large capacity who have fumigated for this species claim a loss of \$5,000 a year. One prominent miller states that the loss due to stoppage while cleaning is incalculable.

The use of hydrocyanic-acid gas as a means of disinfecting mills, warehouses, elevators, and other inclosures has become nearly universal in the principal milling centers, and especially as a remedy for the flour moth. It possesses many advantages over bisulphid of carbon for the same purpose, the principal ones being that the gas can be generated without the aid of fire as in sulphur fumigation, and that it is noninflammable and nonexplosive when generated according to methods now in practice. Hence its employment in mills where there might otherwise be a conflict with insurance companies.

On account of numerous inquiries during the year (which reached as high as five or six daily at times) for advice in regard to the eradication of the flour moth, it was found necessary, as soon as the required data could be obtained, to publish a comprehensive account of the hydrocyanic-acid gas method of fumigation for the control of this pest. This is published as Circular No. 112 (pp. 1-22). In order to make this publication as complete as possible all of the principal topics which were discussed during the year on this process of fumigation were considered in detail, with the result that to date no questions have been asked since its issuance that are not completely answered in the publication.

RICE MILL INVESTIGATIONS.

By request of several rice millers, some mills in southern Texas and Louisiana were investigated. In the course of these investigations, as well as in others conducted both in the Mississippi Valley region and in the Atlantic district, it has been noticed that hydrocyanic-acid gas has one serious defect, and this has been brought out especially during the year. It has very limited penetrative power when used in fumigating sacks of grain and rice. When used under ordinary diffusion, the fact that the greater portion of both clean and weevily rice is stored in sacks under ventilated sheds or in loosely constructed buildings makes the problem of fumigation entirely different from that of the flour mill or grain elevator. If it could be possible to apply hydrocyanic-acid gas and bisulphid of carbon with pressure, as is used in sulphur fumigation by the Clayton process, this problem might be solved. Otherwise it is probable that under existing conditions we will have to depend upon heat as a remedy. Experiments are being conducted in this direction.

MISCELLANEOUS INVESTIGATIONS.

The export docks of Baltimore, Philadelphia, and New York have been visited and investigations have been made of the local condi-

tions and the insects present in both import and export flour and other cereals.

Fumigation of mills, grain storehouses, and bakeries have been conducted in the city of Washington with good success and will be continued as opportunity offers, the work extending into some nearby mills in Virginia.

More inquiries were received in regard to methods for the prevention of weevils in corn and other stored cereals in the South than in several years, and much information was given in regard to this topic. Efforts were made to ascertain to what extent cereals, especially corn, are attacked in the field, and it was found that in many cases field attack is the direct result of storing grain in the immediate vicinity of grain fields or of planting near granaries. Some common practices in the Gulf region, such as "pulling" or "snapping" fodder so as to expose corn ears to the ripening and hardening effects of the sun, tend to increase injury by the Angoumois grain moth and the rice weevil and should be discontinued. Early harvesting, prompt threshing, and storage in bulk all conduce largely to the prevention of infestation. For the rest, cleanliness in the depositories, with fumigation, preferably before storage, will destroy the insects which remain.

A branch of this topic which will sooner or later demand attention is as to the effect of "weeviled" grain to stock and to human beings when taken as food. Practically nothing definite has been done in this line, although it has been known for some time that horses are badly affected by "weeviled" grain and by the "dust," chiefly excrement, occurring in infested oats and other cereals. They also refuse to eat food containing large granary insects, such as the meal-worms. Chickens, swine, and cows do not appear to be badly affected by a moderate amount of this material, but doubtless all would suffer from a larger diet of "weeviled" grain.

In all, the principal seaboard mills and terminal elevators exporting grain and other cereal products from the Atlantic coast have been inspected and the insects infesting export and import cereals have been studied. In addition, various blending plants and factories manufacturing cereal products, and storage depositories, have been kept under constant observation.

The use of bisulphid of carbon, while prohibited by fire-insurance underwriters in many cases, is still in use for other insects than the flour moth, which affect stored products, and in some cases its use is practically necessary; for example, for spraying spouts and other portions of machinery where hydrocyanic-acid gas is unable to penetrate a large mass of flour. It is also used to a considerable extent either before or after hydrocyanic-acid-gas fumigation.

Experiments have been made with sulphur fumigation where it was not practicable to use other means of treatment, and these have been found successful.

During the year upward of 100 reports were received from many of the principal milling establishments of the country giving results of the treatment of the mills by hydrocyanic-acid gas fumigation.

An agent of the Bureau, working chiefly in the States of Kansas and Texas during the year, has submitted more exhaustive reports

on experiments with all of the different methods of fumigation which have been mentioned.

In cooperation with the Bureau of Chemistry, insects injurious to imported dried fruits, and especially Smyrna figs, have been studied. Means for their control have been formulated and the work will be continued.

INSPECTION WORK.

As in previous years, all seeds and plants introduced and distributed by the Division of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, as well as ornamental plants imported by florists in the District of Columbia, have been thoroughly examined. In addition to these, about 2,000 cherry trees, a gift from the city of Tokyo to the Government of the United States, were examined and found to be infested with a number of injurious insects. All of these plants were destroyed. Several insects were collected on plants introduced by the Bureau of Plant Industry, which, if allowed to gain a foothold in Florida or other warm portion of the country, might prove serious enemies to cultivated crops.

In addition to this work carried on at Washington, a somewhat elaborate inspection system for products proceeding from regions in New England inhabited by the gipsy moth and the brown-tail moth has been conducted by the gipsy moth force as indicated in a preceding paragraph.

INSPECTION FOR THE IMPORTED BROWN-TAIL MOTH NESTS.

In the last report the efforts of the Bureau to prevent the importation of brown-tail moth nests upon seedlings shipped from Europe to nurserymen in the United States were described. The extraordinary numbers in which these nests were found upon this imported stock was due probably to the occurrence of the brown-tail moth in certain parts of Europe in most unusual numbers during the summer of 1908. In the summer of 1909 the same conditions existed, and as a result the shipments of nursery stock from portions of Europe in the autumn of 1909 and the winter of 1909-10 again carried many nests. Moreover, upon one shipment of nursery stock from Belgium to Louisiana an egg cluster of the gipsy moth was found. By an especial arrangement, through the kindness of the Secretary of the Treasury, with the custom-houses, and by agreement with the railroads, the Bureau was notified of all cases of plants received, and, as in the previous autumn and winter, secured the inspection of probably every shipment at the point of ultimate destination. Shipments of nursery stock to the number of 291 were found to be infested with nests of the brown-tail moth, and these went to the States of Colorado, Connecticut, Georgia, Illinois, Indiana, Kansas, Louisiana, Michigan, Montana, New Jersey, New York, Ohio, and Virginia. In most of the States inspection was rendered simple by the fact that there were efficient state inspection laws and official inspectors. Notification in such cases from the Bureau was all that was necessary. In other cases where there was no such state service, the inspection was carried on either by employees of the Bureau or by expert collaborators appointed for the purpose.

THE NECESSITY FOR A NATIONAL QUARANTINE AND INSPECTION LAW.

As pointed out in the last annual report, the United States is practically the only one of the great nations of the world which has not protected itself by law from such accidental importations of pests of this character. During the winter an inspection law, based upon the permit system, was drafted and submitted to Congress after consultation with the legislative committee of the National Nurserymen's Association. Thorough hearings on the bill were held before the Committee on Agriculture of the House, but, probably owing to a disagreement on certain sections between the Nurserymen's Association and the officials of the Bureau, the act was not placed upon the calendar.

The hope is again expressed that a satisfactory bill may be drafted the coming autumn, and that it will receive the sanction of both houses of Congress.

In June, 1910, the Chief of the Bureau visited Holland, France, Belgium, and England, in order to look once more into the conditions of growing nursery stock and into the inspection systems in those countries as well. The French Chamber of Deputies failed to pass the inspection law proposed by the ministry of agriculture during the past season, owing to some doubt as to the question of expense. The director of agriculture of France, however, is certain that arrangements will be made in the very near future for the establishment of the competent service referred to in the last report. In the meantime, however, Belgium has established a service, under the directorship of Doctor Staes, of Ghent, which promises efficient inspection in the future. The officials of the board of agriculture in London state that the exporters of nursery stock in Great Britain are willing to have an inspection service started, and it seems probable that the English Government will move in this direction.

The insect conditions in the regions of the large exporting nurseries of France, in the vicinity of Angers, Orleans, and Ussey, were found to be very favorable during June, 1910. For some unknown reason it was with the utmost difficulty that a lepidopterous larva of any kind could be found in the north of France—not a single brown-tail moth caterpillar or gipsy moth caterpillar could be found in any of these nursery regions. The mayor of Angers, during the winter of 1909-10, put in force the hitherto neglected police measures providing for the destruction of every visible nest of the brown-tail moth during the hibernating season. It is quite possible that the efficiency with which this work was carried out has contributed to the clean condition of the Angers nurseries the present season. It seems impossible that the condition of nursery seedlings imported from France during the coming winter can be at all like those of the two past winters, but governmental and state vigilance should not be relaxed on this account, since there are many other European insect pests which constitute dangers to the United States aside from the brown-tail moth and the gipsy moth.

WORK IN BEE CULTURE.

The work in bee culture has been carried on as before under the direction of Dr. E. F. Phillips.

WORK ON BEE DISEASES.

The work of the past fiscal year on bee diseases has demonstrated more clearly than before that this is the most important subject before the bee keepers of the country. The study of the bacteria of the two infectious bee diseases has been continued, with especial attention to the amount of heat and chemical disinfection necessary to destroy the causative organisms. The results are of great value in prescribing methods of disinfecting contaminated material. The drug treatments advocated by European writers have been carefully tested, and it has been found that none of the drugs is of any value in treating American foul brood, even aggravating the condition in some cases. A large amount of work has been done in the effort to establish the cause of European foul brood. Repeated efforts to produce the disease by giving colonies of bees the organisms supposed to be the cause, namely *Bacillus alvei* and *Streptococcus apis*, have been uniformly unsuccessful. The results of the work so far carried on show only that the disease can be transmitted by feeding infected material. Other organisms found in diseased individuals are being studied, and new media are being tried. The disease responds to the treatment recommended for American foul brood, but, until the cause is ascertained, little can be done further on the remedial side.

In the last report it was stated that the effort to learn the distribution of bee diseases in the country would be completed by the close of 1909, but it has been found that these diseases are much more widespread than was supposed, and it will take at least one more summer to make the work complete enough for record. Samples of dead brood suspected of disease have been obtained from all parts of the United States, and during the past fiscal year 620 samples were examined, as against 280 the previous year. The data obtained in this study of distribution are utilized mainly in sending a practical circular on the treatment of brood diseases to all the bee keepers in infected districts whose names can be obtained. Every effort is made to inform the bee keepers in the infested territory how to combat the maladies. This information is also available for use by bee keepers who are applying for the passage of state laws for the inspection of apiaries, since it indicates the need of such legislation.

It has been found that the treatment recommended by the Bureau can be carried out successfully, not only with no financial loss, but often with an actual increase in returns if done in time.

STUDIES OF THE STRUCTURE AND DEVELOPMENT OF THE BEE.

Work on the structure and development of the bee, which was announced in the last annual report, was completed during the year in so far as the anatomy of the bee is concerned, and the results were published in a technical bulletin. A large number of errors of former observers have been corrected in this bulletin. Accurate information concerning bee anatomy is necessary in many lines of apicultural investigation, especially in investigating the physiology and behavior of bees, these lines being of importance in practical manipulation.

Work on the development of the egg stage of the bee has been conducted during the past year.

WORK ON THE-BEHAVIOR OF BEES.

Investigations have been carried on during the year as to the means by which bees find their way to flowers, the source and gathering of propolis, the behavior of bees on unprotected combs, and color vision. These studies of behavior under normal and abnormal circumstances are highly important in devising practical manipulations.

EXPERIMENTS WITH BEESWAX.

During the past year some preliminary experiments on the removal of the beeswax usually left in slumgum were conducted. It was found that there is usually a considerable amount of wax lost in the methods of wax extraction now employed, and an effort is being made to make an apparatus which will remove this wax economically. The extraction of all the wax from combs is most important, since, where disease is concerned, there are many combs to be rendered. Complete extraction would add greatly to the profits of large apiaries. Bee keepers in various parts of the country are cooperating with the Bureau in the collection of samples of beeswax produced during the gathering of different kinds of honey, since it is known that beeswax from different sources varies considerably in its physical properties.

MISCELLANEOUS.

An effort has been made to learn what is being done in this country and abroad in regard to education in bee culture.

A new location for the Bureau apiary has been obtained at Chevy Chase, Md., and the number of colonies is being increased to accommodate the needs of experimental work.

UNCLASSIFIED WORK.

As in previous years, a great deal of work has been done in different directions which can not be classified under the main sections.

Especial attention has been paid, as in previous years, to the study of pecan insects, especially in Texas and in Mississippi. In the same way the insects injurious to ornamental plants have received considerable attention throughout the year.

More work has been done than in recent years on the subject of insects injurious to shade trees. The demand for information in regard to insects of this class is constantly increasing. Circular publications have been issued on some of the more important species, but new forms appear occasionally, and insects hitherto considered of no economic importance occasionally develop in enormous numbers and destroy the shade trees in certain cities. During the past year the European leopard moth has done serious damage to the shade trees of Cambridge, Mass., and vicinity, and a new pest from Europe, the elm scolytus, has made its appearance in the vicinity of Boston. So serious has been the damage of these two imported pests and of the imported elm leaf-beetle that the beautiful elm trees of Cambridge have been dying by hundreds. In June, 1910, 1,000 large trees were removed. The Bureau has endeavored to aid in all such cases by giving advice, and where investigations can be made of

the insects of this class at Washington or at the field laboratories of the Bureau they are carried on incidentally to other work.

The work of the specialists of the Bureau, to which annual reference has been made, in the determination of specimens sent in by state entomologists and other workers in practical entomology has again increased. The interest in the study of insects from the practical point of view has grown enormously in recent years, and Washington, by virtue of its large libraries and large force of entomologists, has become the center for this determination work, which could hardly be done as well elsewhere. Much time is occupied in this work, but not only can this hardly be avoided, but it has a very important bearing upon the practical work of the state entomologists, the teachers of economic entomology, and others engaged in practical work. During the fiscal year more than 26,000 specimens were examined in this way.

The correspondence of the Bureau continues to increase, and, in addition to correspondence by circulars, more than 22,500 letters have been written.

The publications of the Bureau have increased in number, fifty-three new publications having been issued during the fiscal year.

PROPOSED WORK FOR THE FISCAL YEAR 1911.

With the gipsy moth and the brown-tail moth work for the fiscal year 1911, some changes in methods are being considered. Continued effort will be made to reduce the cost of the methods in use along woodland roads, and continued experimentation will be made in the hope of finding some means of caring for woodland regions. An improvement in the method of inspecting products shipped by the railroads from infested regions will be made, and a larger force of permanent inspectors will be established from among the more intelligent of the men at present on the rolls.

With the importation of the parasites of the gipsy moth and the brown-tail moth, the time has arrived to reduce the large bulk of the importations, and in the future to bring over only those species which have not yet been received in sufficient abundance to establish perfect colonies. At the time of this writing an agent is in Europe studying the best methods of bringing this about, and is looking into the question of the autumn life and probable methods of hibernation of some of the species involved. More time will be spent upon the study of the species already introduced, in order to secure a more accurate idea than we have at present of what is to be expected of them in the next few years.

With the cotton boll weevil, investigations along the same lines reported upon for the year 1910 will be continued. The work in the Mississippi Valley continues to be the most important work, but it may be necessary during the coming winter and spring to establish observation stations farther east, on account of the continued eastern spread. Experimental field work, however, will be continued throughout the whole infested area. The work upon tobacco insects, sugar cane insects, and rice insects will be continued as outlined in this report, as well as the studies of the cotton red spider and the cotton root louse in South Carolina and adjoining States.

With forest insects, the investigations of the past fiscal year will be continued. The demonstration work outlined in this report will be carried on as vigorously as the cooperation of the Forest Service and of private owners will permit.

With deciduous fruit insects, the investigations already outlined will be continued to the close of the season, at which time some of them will be concluded. It will be desirable to continue the work with the pear thrips, although the scope of the operations may be lessened. Further codling moth studies are desirable, especially in the Southeast, as in Georgia, which is a coming apple State, and in the Southwest, as in New Mexico and California. Plum curculio demonstration work will probably be continued and enlarged. A study of fruit-insect parasites is to be begun. The establishment of a laboratory in the New England States for the study of the apple maggot and other fruit pests, which was found impracticable in the spring of 1910, it is hoped may be effected in the spring of 1911.

With cereal and forage-plant insect investigations there will be no great expansion of the investigations, but as much attention as possible will be paid to the *Hemileuca* caterpillar damaging stock ranges in New Mexico, and to the alfalfa weevil in Utah.

No new work, except in a small way, will be carried on in insects affecting vegetable crops.

With insects affecting citrus fruits, as already pointed out, the investigation with hydrocyanic-acid gas has been completed; the work upon the orange thrips will be continued, and the work on the white fly will be carried on in about the same way as during the past fiscal year. Congress has made an appropriation of \$5,000 for the investigation in this and foreign countries to discover natural enemies of the white fly, and, in consequence, an expert agent has been sent to oriental regions, where there is reason to believe that the white fly has its original home, in a search for these natural enemies. This mission will probably occupy the greater part of the fiscal year.

Under the work on insects in their direct relation to the health of man and domestic animals, a new series of investigations has been begun on house fly conditions in relation to the agency of this pest in the spread of typhoid fever and other intestinal diseases. Experimental work with mosquitoes will be carried on in a small way. The investigations of the southern cattle tick are being continued. Much important work on the spotted fever tick is under way, having been begun shortly before the close of the last fiscal year. The presence of spotted fever—which is transmitted in nature only by the tick—interferes with the development of large areas of land in the Northwest. The camp laboratory in the Bitter Root Valley will be continued during a portion of the season, and efforts will be made toward obtaining exact information regarding the distribution of the dangerous ticks throughout the territory in which spotted fever occurs. It is hoped that the information gained will enable the residents of the Bitter Root Valley to undertake a campaign of eradication.

The work on insects injurious to stored products will be carried on along the same lines, the only innovation being the sending of an expert assistant to Smyrna to study the conditions under which Smyrna figs become wormy, in the effort to bring about conditions which will enable importers to bring in and sell wormless figs, meeting the provisions of the pure food law.

Inspection work will be continued as thoroughly as possible in the absence of a national law, and in the same manner in which it was carried on during the past year.

In apiculture the work in progress will not be completed for several years, and the same investigations, therefore, will be continued.

PLANS FOR WORK RECOMMENDED FOR THE YEAR ENDING JUNE 30, 1912.

It is hoped that it will have appeared from this report and the ones preceding that the Bureau is accomplishing good practical results, and that naturally its opportunities should be increased. The writer has no hesitation, therefore, in view of plans in sight, in asking for an increase to the lump fund appropriation of \$54,750. It is proposed to expend \$36,000 of this increase in adding to the funds devoted to the investigation of insects injurious to forests. The practical results of this work as displayed in this and the other reports have been noticeable. Until the past year or two the small allotment devoted to this work was sufficient to meet the requirements of the field work, which has been directed toward the determination of the principal insect depredations and practical methods of control. This, however, has been accomplished, and it is desired to render greater service in practical results in demonstration work on a large scale. More experts should be employed, and sufficient means should be given the service to enable it to do its part in the prompt and effective manner required to command the confidence and support that is so essential in securing the effective cooperation of the other branches of the Government service and of private timber owners. Ten thousand dollars of the increase asked for will be devoted to the important problem of the alfalfa weevil, concerning which some information is given in this report. This money should be spent in cooperation with the state authorities of Utah and the other States which will be involved in all probability before the beginning of the fiscal year 1912. With the remainder of the increase recommended, it is proposed to devote \$3,000 to the investigation of southern field crops, especially sugar cane and rice, in addition to the sums already allotted to that purpose; to give \$3,750 to further increase the facilities of investigations of insects injurious to truck crops, and \$2,000 increase to the investigations being carried on against bee diseases.

It is also respectfully urged that the salary of the Chief of the Bureau be increased to \$5,000. The importance and scope of the work connected with the Bureau seem such as to justify this increase.



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